

ATTORNEY DOCKET NO. 35624-94960

PATENT

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

PATENT APPLICATION

BY

PAUL R. STANUCH

FOR

PUMP COMPENSATOR

**Howard B. Rockman
Reg. No. 22,190
Barnes & Thornburg
One North Wacker Drive, Suite 4400
Chicago, IL 60606-2809
Phone (312) 214-4812
Facsimile (312) 759-5646**

PUMP COMPENSATOR

[0001] Background of the Invention

[0002] The present invention relates to a pump. In particular, the present invention relates to a pressure compensated variable displacement pump which can operate at high pressures.

[0003] Positive displacement pumps capture fluid in a chamber and reduce the volume in the chamber to force the fluid from the pump. Fluid pumps create flow while operating on a displacement principle wherein fluid enters an input and displaces to an output via the pump. Fixed displacement pumps discharge fluid in a continuous flow while variable volume pumps discharge fluid in a non-continuous flow, i.e. periods with no discharge.

[0004] Positive-displacement pumps deliver a definite volume of fluid for each pump cycle operation, regardless of resistance, so long as the pump capacity is not exceeded. If an outlet is closed or exceeds the output pressure, the pump drive will stall or the pump will experience breakdown. Accordingly, positive-displacement pumps require a pressure regulator or pressure relief valve.

[0005] Pumps are rated according to the volumetric output which is the amount of liquid that a pump can deliver to the outlet per unit of time at a given drive speed. The volumetric output is usually expressed in gallons per minute. Since the pump drive affects volumetric output, pumps are also rated by displacement.

[0006] Displacement is the amount of fluid transferred from a pump's inlet to the pump's outlet in one cycle wherein displacement is either fixed or variable. In fixed displacement, the output can be changed only by varying the drive speed. In variable displacement, the output can be changed by regulating the pressure control and/or changing the drive speed.

[0007] A typical positive variable displacement pump is a vane pump. Vane pumps use a slotted rotor which rotates within a housing driven by a drive shaft. Vanes slide within the rotor in an expanding configuration from the rotor to push the fluid from the inlet to the outlet. Typically, the vanes are positioned within the slots of the rotor. As the rotor turns, the vanes are thrown outward by a combination of hydraulic pressure and centrifugal force which holds the vanes in contact with a pressure ring which surrounds

the rotor/vanes. The ring is offset by the pressure of the pressure regulator used to control maximum system pressure.

[0008] Vane pumps are typically compact in design and provide excellent horsepower to weight ratios while offering high volumetric efficiencies, good suction characteristics and low noise generation. Accordingly, vane pumps are used in a variety of industries such as machine tools, production and material handling equipment and construction equipment.

[0009] Typically, since vane pumps are a form of variable displacement pumps, the vane pumps use a compensator as a pressure regulator. A compensator changes the displacement of the pump to match the flow system requirement by controlling the pressure. In other words, variable flow is achieved at a constant pressure setting. The compensator senses downstream pressure and adjusts the displacement to meet the desired flow of the system.

[0010] Current vane pumps use two traditional compensators: a spring loaded compensator and a hydraulic compensator. In a spring loaded compensator, a spring assembly connects the pressure ring which surrounds the rotor and vanes and applies a force to the pressure ring. Thus, the spring assembly biases between the pump housing and the pressure ring to create a variable pressure around the rotor and vanes. Based on the spring assembly characteristics such as the spring constant, the number of coils and material composition of the coils, the spring compensator varies the pump output displacement. Typically, the spring constant determines the pressure of the pump. Thus, to create variable flow while maintaining constant pressure, the spring compensator is designed with specific criteria for the desired output.

[0011] A problem with spring compensators, however, is the existence of a pressure limit. Coil spring compensators do not perform at high pressures, such as pressures exceeding 2,000 pounds per square inch (psi). To withstand high pressures, a coil spring compensator would require a burdensome number of coils. The required coils for pressures exceeding 2,000 psi would require a spring housing extending off the pump body at a distance exceeding twelve inches. This extended housing prohibits the vane pump from being used in typical applications because of space constraints of a typical vane pump installation. The spring compensator also applies concentrated loading which

leads to increased wear of the springs and ring. Furthermore, the extended spring housing is unwieldy, leading to increased labor installation. Additionally, the extended spring housing results in increased manufacturing costs. As such, the spring compensator is not economically viable for high pump pressures such as pressures exceeding 2,000 psi.

[0012] In a hydraulic compensator, a valve system uses a piston assembly to sense the system pressure. To vary the flow and to compensate the pressure against the housing, the valve system opens and closes to move the piston assembly against the housing. A problem with hydraulic compensators, however, is contamination. Since the hydraulic compensator requires numerous components comprising the valve and piston assembly, those components are susceptible to failure and fluid leakage. Additionally, the hydraulic compensator requires constant maintenance to check on the valve system, leading to increased maintenance costs.

[0013] Efficient and economic pump systems are crucial for fluid systems. As such, fluid systems require pumps which can withstand high pressures while providing efficient output. Additionally, fluid systems require minimal pump noise due to government regulations to limit noise on assembly/factory floors. Accordingly, a need exists for a pressure compensated variable pump that can deliver high fluid pressures. A need also exists for a pressure compensated variable pump that is compact in design. The solution, however, must be a vane type pump having low noise output. A need also exists for a pressured compensated variable pump that is easy to install. The solution, however, must minimize contamination and maintenance procedures.

[0014] Brief Description of the Drawings

Fig. 1 illustrates in an isometric view an embodiment of the fluid pump device.

Fig. 2 illustrates in a cross sectional view an embodiment of the fluid pump device.

Figs. 3a and 3b illustrate, in a top and side view, pressure elements of the device.

Fig. 4 illustrates in a cut away view of an embodiment of the fluid pump device.

Fig. 5 illustrates in a side view of the pressure elements of the fluid pump device.

Fig. 6 illustrates a cross sectional view of an embodiment of the fluid pump device with the pressure ring in a first position.

Fig. 7 illustrates a cross sectional view of an embodiment of the fluid pump device of Fig. 6, showing the pressure ring in a second position.

[0015] Summary of the Invention

[0016] The present disclosure relates to a fluid pump. In particular, the present invention relates to a pressure compensated variable displacement pump which can operate at high fluid pressures. In an embodiment, the disclosure comprises a pump vane assembly positioned within a housing and a pressure ring positioned around the vane assembly and floating within the housing. Additionally, the embodiment comprises a compensator comprising a guide, a first end, a second end and a plurality of individual adjusting elements. The first end of the compensator adjustably bears against the housing. The second end of the compensator is in contact with the pressure ring, wherein each of the plurality of adjusting elements is positioned adjacent to one another, in series and in contact with the pressure ring via guide shoe to vary the pressure created by the vane assembly against the pressure ring.

[0017] The present disclosure also includes a method of varying pressure comprising rotating a vane assembly within a housing and applying high pressure from the vane assembly against a pressure ring. Next, the method comprises varying the pressure by biasing a plurality of adjusting elements to reciprocate a guide against the pressure ring.

[0018] Detailed Description of the Illustrated Embodiment

[0019] As stated, the present disclosure relates to a pump. In particular, the present invention relates to a pressure compensated variable displacement pump that can operate at high pressures. Fig. 1 illustrates in an isometric view an exemplary embodiment of the present invention generally shown as 10. The present invention 10 comprises a pump 12 having a housing 14, an inlet 16, an outlet 18 and a compensator 20. The compensator 20 is positioned on the top of the pump 12 but may be positioned on other sides of the pump 12. As shown, the pump 12 and compensator 20 are configured together in a compact design to minimize required installation space.

[0020] Turning to Fig. 2, the pump 12 is shown in a cross sectional view, wherein the pump 12 comprises a vane type pump. Accordingly, the pump 12 includes a shaft 22 and vane assembly 23 positioned within the housing 14 wherein the vane assembly 23 includes a plurality of vanes 24 which reciprocate within slots 26 of the shaft 22. Depending on the cycle portion, the vanes 24 extend out beyond the circumference of the shaft 22 varying amounts, as shown in the art.

[0021] A pressure ring 28, positioned within the body 14, has an internal shaft that surrounds the shaft 22 and vanes 24 wherein the pressure ring 28 floats within the body 14. To maintain the pressure ring 24 within the body 14, the pump 12 includes a thrust screw assembly 30 which limits the movement of the pressure ring 28. The thrust assembly 30 includes a thrust screw 32, a lock nut 34 and a thrust bearing 36. The thrust screw 32 extends and retracts within lock nut 34 to position the thrust bearing 36 within the body 14 to contact the pressure ring 28. Thus, the amount of float of the pressure ring 28 within the body 14 is controlled by the stop assembly 30. A fixed stop 37 also assists in controlling the position of the pressure ring 28. The pump 12 further includes a second fixed stop 38 which primarily positions the ring 28 during assembly.

[0022] As shown in Fig. 2, the compensator 20 is positioned on and extends through the body 14. The compensator 20 includes a compensator body 39, a compensator adjuster 40, a plurality of adjusting elements 42, a pivot plate 44, a bearing plate 46, a guide 48 and a guide shoe 50. The guide 48 has a first end 52 positioned near the compensator adjuster 40 and a second end 54 positioned near the guide shoe 50, wherein the guide 48 is hollow between the first end 52 and the second end 54. The plurality of adjusting

elements 42 are positioned around the guide 48 between the first end 52 and the second end 54. Additionally, the pivot plate 44 is positioned between the first end 52 and the plurality of adjusting elements 42 while the bearing plate 46 is positioned between the second end 54 and the plurality of adjusting elements 42. Further, the guide shoe 50 is attached to the second end 54 while contacting the bearing plate 46. The guide shoe 50 is sized and shaped to match an outer circumference portion 56 of the pressure ring 28, as will be discussed.

[0023] Turning to Figs. 3a and 3b, one of the adjusting elements 42 of the illustrated embodiment is shown, wherein each adjusting element 42 has a center 58 and an edge 60. The center 58 is positioned within an aperture 62 while the edge 60 is positioned at an angle from the center 58. Accordingly, the adjusting element 42 has a convex side 64 and a concave side 66. In an embodiment, the adjusting element 42 may comprise a washer such as a Belleville washer. The adjusting elements 42 are sized and shaped to distribute pressure from the center 58 to the edge 60 in a continuous arc pattern.

[0024] Turning to Fig. 4, the adjusting elements 42 are positioned in series. The series comprises a plurality of stacked sets of adjusting elements 42, each set containing one adjustment element 42 having its side 66 (Fig. 3b) facing pivot plate 44 and the second adjusting element 42 having side 66 (Fig. 3b) face the bearing plate 46, thus forming a multiple cup-like stack having an inherent resilience. As shown in Fig. 4, the adjusting elements 42 are individual elements aligned with each other around the guide 48 between the first end 52 and the second end 54 (Fig. 2). The pivot plate 44 is also shaped similar to the adjusting elements 42 such that the first or top most adjusting element 42 is positioned near the pivot plate 44. The bearing plate 46, however, is sized and shaped in a flat configuration.

[0025] Turning to Fig. 5, the adjusting elements 42 are shown aligned in a series described above around the guide 48. In this alignment, the convex sides 64 of adjacent adjusting elements 42 are in contact with each other. Accordingly, the concave sides 66 of adjacent adjusting elements 42 are oppositely positioned with each other. As such, the concave side 66 of the first adjusting element is positioned opposite both the pivot plate 44 and the bearing plate 46.

[0026] During use, the compensator 20 maintains a constant pressure pump while matching flow displacement demands of the pump 12. Hydraulic forces cause the ring 28 to move against the guide shoe 50 wherein this movement is restricted by the adjusting elements 42. Turning to Figs. 6 and 7, the plurality of adjusting elements 42 bias the guide shoe 50 downward to reciprocate between a first position (Fig. 6) and a second position (Fig. 7) in tandem with the pressure ring 28.

[0027] Since the pressure ring 28 floats within the body 14 and the shaft 22 rotates in a fixed position within the housing 14 and the fluid between vanes 24 applies a pressure to the internal surface 29 of pressure ring 28, the pressure ring 28 may move in an axial direction and becomes more or less separated from portions of shaft 22 during a portion of the pump cycle. As the shaft 22 rotates, the vanes 24 extend out of the slots 26 to pick up fluid from the inlet 16 (shown in Fig. 1). The vanes 24 then displace the fluid toward the outlet 18 (shown in Fig. 1) creating a high pressure fluid area 68 between the shaft 22 and the pressure ring 28.

[0028] To adjust for the high pressure generated in the pump and to maintain a constant fluid flow output, the adjusting elements 42 bias the guide shoe 50 against the pressure ring 28 as shown in Figs. 6 and 7. Accordingly, the guide shoe 50 moves from the first position in Fig. 6 to the second position of Fig. 7. Thus, the high pressure developed in area 68 is distributed from the center 58 to the edge 60 of the adjusting elements 42 (Fig. 3a). The adjusting elements 42, in turn, are sized, shaped and combined in a stack to compensate for pressures exceeding 500 psi, which biases the guide shoe 50 in tandem against the pressure ring 28. In an embodiment, the adjusting elements 42 are sized, shaped and configured to compensate for pressures exceeding 2,000 psi. In an embodiment, the adjusting elements 42 are sized, shaped and configured to compensate pressures up to and including 3,200 psi.

[0029] In comparing Figs. 6 and 7 during a cycle, the plurality of adjusting elements 42 bias the guide shoe 50 against the outer circumference pressure ring 28 to compensate for the high pressure created by the vane assembly 23. In this series configuration of elements 42, the convex sides 64 of adjacent adjusting elements 42 are in contact with each other and the concave sides 66 of adjacent adjusting elements 42 are oppositely spaced apart and facing each other (see Fig. 5), the plurality of adjusting elements 42

maintain the bias force necessary to compensate for high pressures in a stack of relatively short axial dimension. The plurality of adjusting elements 42 are sized and shaped to maintain a bias force up to and including 3,200 psi. Additionally, since the individual adjusting elements 42 are aligned in series around the guide 48, the compensator 20 maintains a minimal extension beyond the body 14. As such, the compensator 20 and the adjusting elements 42 provide a compact vane pump which can withstand high pressures.

[0030] While the concepts of the present disclosure have been illustrated and described in detail in the drawings and foregoing description, such an illustration and description is to be considered as exemplary and not restrictive in character, it being understood that only the illustrative embodiments have been shown and described and that all changes and modifications that come within the spirit of the disclosure are desired to be protected by the following claims.